

A Critical Review of Alternative Sources of Energy towards Sustainability

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Abstract: -The need of production of energy to fulfill the present needs without compromising the needs of the future generations has attracted a lot of attention in the past few years. This paper presents a critical review of the fuels that are presently used for the generation of energy, and those fuels that are yet to be exploited to their maximum potential. This research paper has been segmented into

- 1) Fuels of the present and;
- 2) Fuels of the future

That has focused on renewable fuels used in the present, like hydropower, wind power and solar energy. It also analyses some of hydrogen and extraction of energy from Lightning.

Finally, this paper entails the energy resources for both the current and the forthcoming generations. It also focuses on the plan of action that every individual must follow to prevent the exhaustion of the conventional fuels and for the better utilization of fuels that have not yet been exploited fully. Hence sustainably managing resources, so as to provide better lifestyle to the people without compromising the needs of their children.

Keywords: *Renewable resources, biogas, biodiesel, lightning, solar energy.*

I. INTRODUCTION

In an era where there is an escalation in the demand for energy and decline in the resources available, there is a crucial need to produce energy that is sustainable. Here, the energy produced has a much lower environmental impact and does not run out unlike the conventional sources of energy (Abolhosseini et al, 2014). The renewable energy investments are used to maintain the facilities, on workforce and materials rather than expensive imports. Hence it creates employment opportunities rather than going overseas. The oil that is being purchased from other countries increases our dependence on imports (IPCC, 2011). Hence we have devised some methods to create sustainable energy by harnessing the sun (solar energy), wind, rivers and streams (hydroelectric power), biomass (bioenergy), hydrogen, geothermal energy and ocean energy (Panwar et al, 2010). IEA (2012d) comprises of some important global tendencies that could drastically affect utilization of sustainable technologies. Firstly, as the viable electricity escalates in terms of magnitude it should also

spread out topographically. Secondly, there is a tough competition between the conventional sources of energy and the sustainable energy on economic terms. When discussing the clean technologies there are two concepts to keep in mind: energy supply technologies (like wind and solar energy); and energy efficiency technologies (employed to magnify energy use efficiency) (Abolhosseini et al, 2014). This concept of replacing conventional energy technologies with clean, sustainable technologies is evolutionary associated with the change in technologies and formation of markets.

II. LITERATURE REVIEW

The need for energy that can be regenerated and used in a cleaner and sustainable manner has attracted a considerable amount of attention in the present times. This need has given led to the advancement of certain types of generable energies. Given below is a list of renewable sources of energy:

A. Hydropower

In terms of renewable energy, hydropower is considered to be the largest around the world with efficiency more than 90%. Today hydro power development has become challenging due to large initial fixed investment cost and environmental problems. Also, these projects have often been problematic for the local residents who had to be relocated. Also the construction of dams is permanent with a sunk cost of utilities (Elbetran et al, 2012). Hydro power is advantageous because of preexisting supply for farming, household and industries. It provides a depot for both water and energy. The water is in turn used for both base load and peak time power generation. Hydropower plants are mainly of three types: run of river (Because of the flow of river power generation takes place), reservoir (production of power takes place), pumped storage (the water is pumped again) (Abolhosseini et al, 2014). 3,329 TWh of electric power was generated in 2009 which was a share of about 16.5% of the electricity in the world. The national electricity generation has of about 160 countries has hydropower involved in it according to World Energy 2010 report (Kaunda et al, 2012). for example the capacity of Itaipu dam, which is the largest capacity hydropower plant was installed on the river Parana had increased from 12.6 GW in 1984 to 14 GW in 2006 (Ngo and Natowitz, 2009).

Table I. Research about hydropower generation

AUTHORS	TOPIC	CONCLUSION
Sinha (1992)	The modeling of power system economics	Application of water and wind systems is not greatly affected by pumped storage but can be used for sites which do not have natural inflows.
Paish (2002)	Hydropower technology in small scale	The main pros of this kind of technology is that it gives out more concentrated energy and can be used whenever required
Kaunda et al (2012)	Hydropower as a source of renewable energy	Hydropower is advantageous economically and environmentally. It is technologically feasible and can be used as storage for energy.
Yang and Jackson (2011)	PHES in USA: advantages and disadvantages	It is negatively affected by the usage of biogas but new laws regarding price can reduce the negative impact.
Abolhosseini et al (2014)	Review of energy efficiency technologies and their supply.	Due to the expanding need for energy, renewable energy sources are important and should be utilized to the maximum potential.
Monteiro(2013)	Small scale hydro model for power generation	Power production forecasts are necessary to prepare maintenance schedule and bid offers in any hydro plant.

B. Wind Power

The use of wind as a renewable resource has increased globally with wind turbines being erected on mountain ridges, in the ocean and on agricultural land with over 120 GW of energy being produced (Mroz, 2010). Its basic function is to convert the power in the wind and convert it into rotational energy by means of aerodynamically designed plates, which can be used to drive a generator (Panwar et al, 2010). The countries where most wind turbines are erected include China, US, Germany with cumulative installed capacities 62, 47 and 29 GW respectively (Abolhosseini et al, 2014). Its capacity will be elevated from 238 GW in 2011 to 1100 GW by 2035 according to the IEA estimates (IEA, 2012e). The advantages of this renewable resource include continuous supply of energy at a constant price in developing countries like Africa. It's been estimated that the net annual CO2 emission mitigation potential at a mean wind speed of 4.5 m/s is the lowest (2874 kg) for GM-II model and highest for SICO model in case of diesel substitution (Panwar et al,2010).

C. Solar Energy

Energy is emitted by the sun at a rate of 3.8×10^{23} kW and about 1.8×10^{14} kW is absorbed by the earth's surface. Hence it is one of the most abundant type of renewable energy source and can be used in domestic applications such as cooking as well as in industrial applications. (Panwar et al, 2010). The

photovoltaic market has made progress from 9564MW in 2007 to 59371 MW in 2011. The worlds capacity has increased by 30 GW due to 30GW of new capacity installed worldwide (IEA, 2012c).

Table II: Research about wind power generation

AUTHORS	TOPIC	CONCLUSION
Lenzen and Munksgaard (2002)	Life cycle analysis of wind turbines	It proposes hybrid technologies that can reduce irregularities.
Crawford (2009)	GHG emission of wind turbine and evaluation of its life cycle	For the development of life cycle energy performance of a wind turbine, its size is not of much significance.
Mroz et al (2010)	Assessment and production of wind power in Mongolia.	Development of wind power is important for the growth of the economy.
Sundraragavan and Baker (2012)	Assessment of technologies for the storage of wind power	The assumptions of the authorities about the interest rates directly influence the choice of technologies.

Solar cooking saves firewood and thus saves 38.4 billion million tonnes of carbon di oxide per year from being emitted. The solar water heater of a capacity of 1001 emits about 1237 carbon di oxide in a year at 50% utilization and thus should be used whenever possible to achieve a foreseeable future. The major disadvantage of this type of renewable source of energy is that it is weather dependent and the cost of converting solar energy in to electricity is higher than conversion of fossil fuels into electricity (Panwar et al, 2010).

Table III: Research about solar energy production

AUTHORS	TOPIC	CONCLUSION
Nieuwenhout (2001)	Applications of solar systems for domestic purposes in developing countries	The main hurdles to the utilization of solar energy are limited choice of size, lack of experience of the user etc.
Margolis et al (2006)	A review of nontechnical barriers to usage of solar energy.	The high initial cost, lack of awareness and maintenance issues are some of the barriers due to which solar energy has not been exploited fully
Panwar et al (2010)	Renewable energy for the conservation of the environment	It is important to use renewable sources of energy like solar energy in place of conventional fuels for sustainable development
Huo et al (2010)	The connection between PV market and its manufacturing	The modernization scale is greatly affected by escalation of market scale and the expediency of the PV system will be directly affected by its geographical expansion.

D. Fuels for the future

The above listed renewable energy sources are basically those fuels which are exploited in the present day. There are some energy sources which have to be developed for the future use as they have a vast potential. Some of them are listed below:

1. Biogas

Instead of disposing the cow dung and other animal-plant by products into water bodies or by incineration a bio gas plant is used which uses the anaerobic digestion to convert it into energy. Hence, biogas is an alternative fuel mostly comprising of methane (60%) and carbon di oxide (35-40%) (Abdeshahian et al, 2016). It is formed by the process the anaerobic degradation of organic compounds that live as syntropy releasing biogas (Anaerobic Digestion).

A biogas plant would be advantageous in the present scenario because:

- 1) It is ecofriendly.
- 2) It generates a good amount of biogas which supports the dwindling energy resources.
- 3) Produces high quality manure which is an excellent soil fertilizer.
- 4) Biogas is an odorless, colorless, flammable gas and can be used as a source of natural gas.

Nitrogen and phosphorous are present in these wastes in very high amounts. These elements cause nutrient imbalance in the soil and hence are hazardous if not managed suitably. Also, livestock manure contains deadly substances which in turn could lead to the outbreak of human diseases like heavy metals, growth hormones and antibiotics. Hence the treatment of these wastes by AD method is not only beneficial but is necessary in the present scenario (Abdeshahian et al, 2016).

The main biogas produced which is used for power generation globally is methane which can be used to power both SI and CI engines. SI engines are very sensitive to the composition of biogas leading to high cycle to cycle variations. The low energy density and cetane number along with high auto ignition temperature of biogas restricts its usage in CI engines. Nevertheless, it can be used under dual fuel mode (DFM). The pilot fuel (liquid) initiates the combustion of the primary fuel (gaseous). By varying the flow of quantity of biogas power output of the engine can be controlled and can be replaced up to 85% (Bora, 2015). Hence biogas is one of the most environmentally attractive substitutes for diesel fuels.

Table IV: Research about biogas production

AUTHOR	TOPIC	CONCLUSION
Afazeli et al (2014)	Potential of biogas generation from livestock.	Renewable energy sources like bio gas are an absolute necessity to solve present environmental crisis and stabilization of biogas as an industry can also provide employment.
Bora et al (2015)	Development of	Development of IT of pilot

	compression ratio and injection timing of raw biogas powered engine	fuel along with high CR is a useful innovation in the field of utilization of biogas for sustainable development.
Abdeshahian et al (2016)	Generation of biogas from animal waste in Malaysia	The treatment of farm animal waste on only helps reduce the negative impacts on the environment also creating an energy source that conserves it.
Kavitha et al (2016)	Innovation in the area of production of biogas and its performance on municipal waste	suggested the idea of expansion of dispenser induced microwave pretreatment of WAS on basis of SS reduction and COD solubilization.

2. Biodiesel

The term biodiesel is defined as “ the mono alkyl esters of long chain fatty acids derived from renewable lipid feedstock such as vegetable oils or animal fats for use in compression ignition (diesel) engines” (National Biodiesel Board, 1996).

In most developing countries inedible plant oils are used to generate biodiesel because the edible seeds are consumed by their population (e.g.:- India) or economy (e.g.: - Africa).

Some examples of raw seeds used for bio diesel generation are sunflower, rapeseed, palm, soybean, peanut, linseed and also animal fats. (Romano et al, 2011)

The advantages of biodiesel over conventional fossil fuels are : (The biodiesel board, 2009)

- 1) Can be generated easily by domestic and generable resources.
- 2) It is energy efficient. The total fossil fuel energy given by biodiesel is 320% vs 83% of petroleum diesel (National biodiesel board, 1998).
- 3) It can be directly utilized in engines.
- 4) Is biodegradable and ecofriendly.
- 5) Can be used to clean out tank sediments and fuel line since it’s a good solvent.

The disadvantages of biodiesel are: (biodiesel board, 2009)

- 1) Experiences higher consumption due to lower calorific value.
- 2) Higher NOx emission
- 3) Higher freezing point
- 4) Less stable
- 5) If it’s used in pure form it may degrade plastic and other material. Replacement with Teflon is recommended.

Some methods to reduce the effect of these drawbacks of pure biodiesel are:-

1) BLENDS-

In 1980, Caterpillar Brazil employed 10% bio oil in pre combustion chamber engines without any modifications to it. This experiment was successful with B20 (20% bio oil and 80% diesel) or B50 only (Ma et al, 1999).

1) PYROLYSIS (THERMAL CRACKING)

It is the anaerobic decomposition of organic matter in presence of a catalyst. Triglycerides produced in this manner result in alkanes, aromatics, carboxylic acids, and alkenes. This method is simple, effective and wasteless but the pour points carbon residues and ash content values obtained from this method were unsatisfactory. (Atabani et al, 2012)

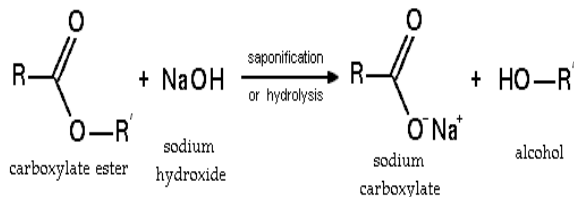
2) MICRO EMULSION

It is defined as “colloidal equilibrium dispersion of optically isotropic fluid microstructure with dimensions 1-150 nm range formed spontaneously from two normally immiscible liquids and one and more ionic or more ionic amphiphilics.” (Atabani et al, 2012)

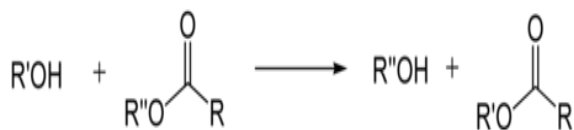
This kind of production technique has met maximum viscosity requirement as that of the diesel fuel and has excelled in both short term and long term engine performance.

3) ALCOHOLYSIS (TRANS ESTERIFICATION)

A triglyceride reacts with an alcohol to generate esters and glycerol. During esterification, the triglyceride reacts with an alcohol in presence of a catalyst to form a strong alkaline.



The alcohol reacts with fatty acids to form mono alkyl ester/ biodiesel/ glycerol.

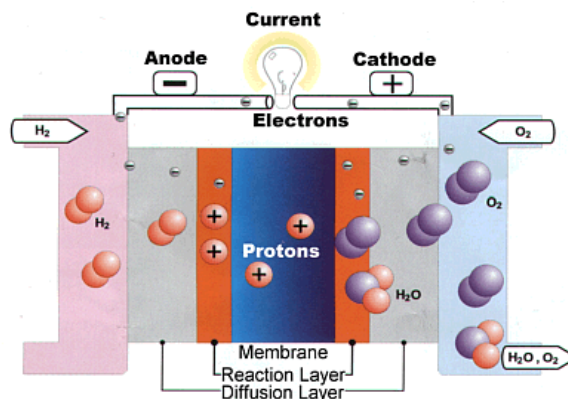


In most experiments methanol/ ethanol are used and are base catalyzed by sodium/ potassium hydroxide. (Borugadda,2012)

Table V: Research about biodiesel production

AUTHORS	TOPIC	CONCLUSION
Ma et al (1999)	Production of biodiesel	Biodiesel can most effectively substitute other conventional energy sources and can be lifesaving in marine and mining where lower pollution levels are needed.
Basha et al (2008)	Review on combustion, performance, emission and generation of biodiesel.	Biodiesels have similar combustion characteristics to that of diesel. Vegetable oils have inferior engine performance and should be substituted with refined oil blends.
Fazal et al	Study of biodiesel	Biodiesel provide more initial

(2010)	feasibility	lubricity, improve combustion and have higher brake thermal efficiency.
Amatucci et al (2010)	Biodiesel production	A sustainable and profitable artificial market with institutional support is mandatory.
Romano et al (2011)	introduction to biodiesel generation	Because of biodiesels being advantageous their production is also of utmost importance.



3. HYDROGEN

Due to hydrogen’s characteristic low density it can be a justifiable emission free transportation fuel and hence is a topic of debate and discussion at a global level (Clamouis,2009).

Significance of hydrogen Fuel Cell Electric Vehicle (FCEV)

- 1) It is an important step to our portfolio of sustainable transportation options.
- 2) It is cheaper, more efficient and cleaner fuel compared to other conventional energy sources.
- 3) It causes reduction of our dependence on imported oil and diversifies energy options.
- 4) Enables growth of economy and global leadership. (NREL,2011)

Working of a fuel cell

A fuel cell may be defined as “A fuel cell is an electrochemical energy conversion device that converts hydrogen and oxygen into electricity and heat. (Estela, 2001) ” An anode, cathode, electrolyte and a catalyst are the elements in a PEM cell. A cathode is positive and gives out oxygen while the electrolyte is the Proton Exchange Membrane (PEM). The catalyst is responsible for changing the rate of the reaction.

At anode the hydrogen gives out protons (temp: 80 deg Celsius):



At cathode:

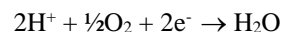


FIGURE 1: PEM Fuel cell. Source: <http://www.tf.uni-kiel.de/matwis/matsci/project/fuelcells/>

Hydrogen storage

1) Bulk storage in distribution system

It can be stored in both gaseous and liquid forms. Gaseous hydrogen can be stored in underground caverns and in depleted natural gas formations because these methods prevent leaking of hydrogen. For example town gas mixture containing hydrogen has been stored in a cavern in France and helium in Amarillo, Texas.(Dincer,2008)

Above ground, high pressure storage tanks are another option. Modifications in pressure in pipelines (distribution system) may also help in storage of hydrogen

2) *Hydrogen storage in end life*

The four main methods of storing hydrogen for an appreciable duration of time are:

- Compressed gas
- Cryogenic liquid
- Metal hydride
- Carbon adsorption

Safety issues regarding hydrogen (ICFHE)

The main issues with hydrogen powered vehicles are electrical shock and flammability of the fuel. (ICFHE)

- 1) Since over 350V is needed for drive train of fuel cell and the material used in vehicles has a good amount of electrical conductivity, this fuel poses a serious threat to life and property if not managed suitably.
- 2) Faulty computer or electrical system may cause the vehicle to change the direction, engage brakes or the motor.
- 3) Hydrogen, being an energy dense fuel has the tendency to disperse very quickly under normal pressure. Hydrogen atoms can easily escape through hole and can make even steel brittle over time. Besides, the thin membrane used on PEM fuel cells can lead to direct combustion of hydrogen and oxygen. In vehicles operating under normal conditions, the accumulation of slowly escaping hydrogen can pose a serious threat to life and property.
- 4) At normal pressure and temperature per unit energy of hydrogen takes up large space. This problem is solved by reforming different hydrogen fuel resources.

4. *LIGHTNING*

The transfer of electrons which generates a tiny shock is static electricity. Lightning is nothing but static electricity except on much bigger scale.

The turbulence in the clouds causes the clouds to separate (conditioned by thunderstorm). This causes the concentration of negative charges at the base of the clouds and positive charges are developed on the earth's surface. This leads to creation of an electric field between the clouds and the earth's surface. The air around the cloud gets ionized and a streamer begins to proliferate down towards the earth's surface. The negative charges are much smaller than positive charges and move toward the earth by creating a Stepper ladder. As this

ladder approaches earth's surface, the electric field develops more at sharp edges. It is propagated by an ionizing wave of ground potential that propagated the previously charged ladder channel (also called as the First Return Stroke).

The electric field between the cloud and ground potential generates the additional ionization. Thus, current flows between the earth and the cloud in small discharge which reiterate through the eye. (Srinivasan et al, 2006)

Lightning as a source of energy

Lightning can be tapped with a lightning rod and fed into an isolator circuit which may further be steeped down a number of times by a step down transformer. This can be guided down through thousands of turbines each producing 15 times more power than original capacity. The flaws in this plan are that we do not know where the lightning would strike. Also, the initial investment to build each lightning rod would be too high. (Notenboom, 2014) As promising as it sounds, further research needs to be done on this type of energy source.

Table VI: Research about extraction of energy from lightning

AUTHORS	TOPIC	CONCLUSION
Srinivasan et al (2006)	Lightning as a form of atmospheric electricity	It focuses on the formation of lightning stroke from thunderstorms and its pros and cons.
Rakov et al (2009)	The progress in protection and research of lightning	Lightning, in spite of having such vast potential can be hazardous to human life and property if not managed suitably.
Farriz et al (2010)	A new source of energy from lightning stroke	It suggests a certain model, that if developed into a large scale system, can become a method of extraction of energy in the upcoming years.
Helman (2016)	Extraction of energy from lightning	Some methods of catching lightning are: building a tower and the usage of rockets or lasers to target strikes.

III. CONCLUSION

This paper focuses on the need of sustainable energy sources for present and future generations and the impacts they can have in the future if exploited suitably.

The government and citizens should work together for this to happen. The ruling party of the nation should be acceptant to these ideas and help the country adapt with the changing times. Awareness should be spread about the depletion of fossil fuels and their adverse effects on environment.

In rural India, the use of firewood as a fuel is still very common. So what goes under the pot costs a lot more than what goes in it.

This paper also discusses some fuels which are not yet utilized to their maximum potential. This is the area where more and more research should take place. With time these sources will also be feasible to man and energy will be extracted from them also.

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